

New Insights into the end-User Requirements for Remote Monitoring for Aging at Home Contributions to the Third Digital Divide

Cosmina Paul^a, Andreea Stamate^b and Luiza Spiru^c
Ana Aslan International Foundation, Spatarului nr 3, Bucharest, Romania

Keywords: Older Adults, Gerontographics, Monitoring, Digital Divide, Data Ethics.

Abstract: Well-being and independence are highly valued in Western European countries. Though, we need a more in-depth understanding of how older adults and their next of kin perceive how monitoring technologies can support ageing at home. Older adults are the most heterogeneous population in terms of health and functional status comparative to all the other age groups and their formal and informal caregivers need also to be accounted for in this endeavor. Therefore, the understanding of the process of accepting and adopting new monitoring products is cumbersome as the current low adoption rates show despite innovators promises. By employing a gerontographics approach, we aim at understanding what are the older adults' expectations from remote monitoring, a growing industry but with a low adoption rate. Hence, we have concluded that a) all categories are interested in alarm features rather than day to day monitoring, b) the more independent one is, more interested is in controlling/ handling the device, c) those psychologically well are rather stressed about monitoring and prefer not to trade their privacy for safety, all next of kin are much interested in high data accuracy. We have also noted that the first and second digital divides, related to costs and relevance, persist, and they add up to the third one. The third digital divide is about to happen, with respect to data and ethics of the technologies, the need of the older adults or their next of kin to control and understand the device.

1 INTRODUCTION

At the outburst of the Covid-19 pandemic, people reacted emotionally by singing songs out of their balconies – a strong emotional response to an essentially medical issue. However, in time, due to lockdown measures, these emotional responses faded away and people adjusted to technology-mediated communication. Placing our focus on the alleged impact of technology on emotions, the overall aim of our project is to contribute to the understanding of how technology affects the way we care. What are the challenges brought by new technologies – such as diminishing human contact – to the way we are and feel being cared for, and our capacity to care for others?

On the same par, the world population is ageing (Eurostat, Ageing Europe, 2020). Worldwide, there is a sharp increasing in the need for care and the Covid-19 pandemic exacerbated this need (Power, 2020;

Alharbi et al, 2020). It is not only that there are just fewer family caregivers available to provide everyday assistance, but many of them are experiencing their own physical and mental health challenges, at a rate that can be as high as 70-80% (Alex Mihailidis, ICT4AWE, 24-26 April, 2021).

As the wide range of implications of increasing numbers of the older population is becoming a public agenda, the need for technology adoption, as a solution to face this problem, increases as well.

Literature shows that remote monitoring technology, coupled with care-coordination, has the potential to revolutionize the way older adults are “Aging in Place”. This belief led to a context where:

a) Remote patient-monitoring industry is growing and there is still high demand and b) All these technological solutions are designed to complement the increasing need for care which is answered through: at-home caregivers, nursing homes, or PERS devices (PERS personal emergency response

^a <https://orcid.org/0000-0003-3827-2290>

^b <https://orcid.org/0000-0002-3385-9714>

^c <https://orcid.org/0000-0002-5308-205X>

system).

The success of remote monitoring technology is allegedly given by the degree of being perceived as unobtrusive and/or non-stigmatizing. Hence, independent older adults would prefer devices which are not wearable but passive – (More passive, more successful, Vedantam, 2021) and, more, able to detect a range of emergencies, and require no or minimal action on the part of the user (Rantz et al, 2013; de Bruin et al, 2008).

On the same part, the perception of the product by the caregivers is equally relevant. They need to clearly understand the degree to which the assistive technologies give them peace of mind and ease their burden. Hence, older adults' monitoring is meant to support reducing caregiver burden and preserving well-being outcomes for older adults (Czarnuch and Mihailidis, 2011; Marasinghe, 2016; Creber et al., 2016).

With respect to the professional care providers, beyond their effectiveness, performance also increases as more time is allocated to implementing interventions. Along these advantages there are also some limitations of remote monitoring, which refer to

a) high costs, b) the impossibility to assess the performance of an individual, and c) accuracy is limited because the collected data is rather inferred.

If we closely look to the evolution of remote monitoring, we see that it encompasses the advantages and limitations of the first and second grey digital divides, which have been already discussed at large within the research milieu (Karahasanovic' et al, 2009; Delello et al, 2017;

Battersby et al, 2017). The first refers to the low adoption of the technology by the elderly because of high costs, while the second divide refers to the suboptimal adoption of technology by the elderly because of new products' lack of relevance to them. van Deursen et al (2015) are discussing the upcoming of the third divide of technology adoption which relates to a lack of theoretical development about which types of people are most likely to benefit from technological innovation.

In our view, the first and second digital divides gave not been overcome but, more they contribute to deepen the third one. The answer for understanding the correct status of the digital divides relies in the right older adult population segmentation and co-creation process, specifically involving older adults to contribute from the concept development phase, rather than only in the stages of testing solution as end-users.

2 RESEARCH METHODOLOGY

2.1 “Theoretical Framework”

We employ a gerontographics segmentation, which suggests that rather than considering age per se, more accurate and relevant data are to be obtained when accounting for physical and psychological state of the older adults. Gerontographics is an approach developed by Moschis (1996) and it shows its efficacy in analysing elderly' consumer activity based on their physically and psychologically state (Nimrod, 2013; Sthienrapapayut et al, 2018). Therefore, Moschis refers to four categories of older adults which are selected based on their state of health on a continuum from independency towards dependency (Moschis and Mathur 1993; Moschis 1996, 2003;). The approach assumes that older adults show similar behaviour consumer activity if they had encountered similar circumstances, experiences and past events, based on the type of aging experience.

Starting from the gerontographics segmentation, we have found that in the case of older adults psychologically well, the 'Perceived Usefulness' of a new technology determines the acceptance or rejection of a technology, while in the case of those psychologically unwell, the influence of the formal and/or informal caregivers is decisive (Paul and Spiru, 2021).

For example, if a person is overall physically and psychologically well, then the A4A Solution needs to detect the transition towards either physically well and psychologically unwell or physically unwell and psychologically well.

MoSCoW Prioritization for Older adults psychologically well. Must have: Limited usage: just for a notification or alarm, The option to control the device; Easy to install; Reliable alarm.

MoSCoW Prioritization for Older adults psychologically NOT well: Pre-alarms; Basic ADL identification, toileting or feeding; (Individualized) Movement behaviour patterns.

Tak et al (2013) presents a meta-analysis of the association between physical activity (PA) and the incidence and progression of basic ADL disability (BADL) positioning PA as the most effective preventive strategy in preventing and reducing disability, independence and health care cost in aging societies. More, functional independence influences emotional wellbeing, while emotional well-being predicts subsequent functional independence and survival. For example, Ostir et al (2015) support the concept that positive affect, or emotional well-being, is different from the absence of depression or negative affect. Their study results show that positive

affect seems to protect individuals against physical declines in old age. Katt et al (2009) shows that ability to perform ADLs has little to do with cognitive well-being, but is an influential factor in determining emotional well-being.

Hence, to support aging at place and prolong the independence of the elderly, we need to consider both physical activity and emotional wellbeing for functional independence.

But geriatric wellbeing, positive ageing, wellness for the elderly or successful aging are, generally, concepts assessed through both objective and subjective indicators. Therefore, we define wellbeing as the capacity of an older adults to at least maintain/preserve their ADLs to the specific gerontographics category to which they belong. Hence, the transition to a different category is prevented, slowed down or even reversed due to the dyad of OA/NoKs and OA/PCP supported by A4A remote monitoring system.

2.2 Methodology

Within the framework of the project “From Smart Home to Care Home – AAL4All (A4A)”, co-funded by the European Programme AAL (Active Assisted Living – ICT), we have set up and undertook the documentation and co-creation process from its very inception and carried it out over the course of 2022.

We have taken a questionnaire-based survey method, which is part of the Positivism research approach, along with the explanatory design. The data was collected through a semi-structured survey questionnaire. The survey questionnaire was circulated to respondents electronically through internet and traditional hard copies. For electronic distribution, Google Forms have been used and no personal data have been collected.

However, each participant has been properly informed on the purpose of the research and given the possibility to withdrawn at any time. The data was analysed using SPSS.

The survey was conducted by the end-user organizations involved in the A4A project, in Romania, Switzerland, Portugal and Denmark. The survey was carried via online and face2face interviews during the period of May to July 7, 2022, from a sample of 202 adults. 107 participants are from Romania, 32 from Portugal, 27 from Switzerland, and 36 from Denmark. Respondents ranged in age from 18 to 99 years (mean = 57.88 years, sd = 18.61 years), with more than half (66.3%) female. Slightly more than one-third of respondents (37.6%) reported living alone, while nearly one third live with their spouse (27.7%).

Of those sampled, the adoption of the technology which supports independence at home and quality of living is low. 76% did not adopt any technology and from those who did, smartphones and computers are the most common adopted technologies.

The 7-Questions. Respondents were asked seven questions relating to the relevance of various A4A Solution features, in their quality as a care giver or a care-receiver. The participants were asked to rate the relevance of 7 features of the A4A Solution, on a scale from 1 to 5. The mode (the most frequent value) is 5 for each item (the participants rated the relevance of each of the 7 features on a scale from 1 to 5).

The 7-question item which was asked is the following:

How useful is the A4A device, for you or for somebody you care for (e.g. your parents)? To send a notification to a relative or carer if you (or your care-receiver) did not get out of bed by a specific time in the morning.

To know the Activities of daily living based on the sound monitoring (eating, toileting, etc.), Proactively generate an ALARM to the sounds "HELP" or repetitive beats which might mean "HELP" to a next-of-kin or professional carer, Identify the abnormal movement behaviour (for example, overnight or high toilet frequency, To switch off and on the device as you (or your care-receiver) want, Early identification of depression or anxiety, Early identification of cognitive decline.

Participants

From the perspective of gerontographics segmentation the population of people aged 65 and over can be grouped in 4 categories, based on the wellness or unwellness of their physical and psychological status. Therefore, there are 4 categories:

1. Physically and Psychologically Well (Healthy Indulgents)
2. Physically Unwell and Psychologically Well (Ailing Outgoers)
3. Physically Well and Psychologically Unwell (Healthy Hermits)
4. Physically and Psychologically Unwell (Frail Recluses)

Individuals may move to the next life-stage due to biophysical and psychosocial ageing process (Moschis, 2019). That means that generally, someone who is physically and psychologically well, through the ageing process, in time, will become either

physically or psychologically unwell or both.

90 participants fell into the first category, (who identify or self-identify as A4A beneficiary) being physically and psychologically well. The group of those who are physically and psychologically well is over-represented comparative to the other groups. 44% live alone.

The second category comprises 30 participants, who identify or self-identify as being physically unwell and psychologically well. 70% are female.

The third category comprises 25 participants, who identify or self-identify as being physically well and psychologically unwell. 64% are female.

The fourth category comprises 23 participants, who identify or self-identify as being physically and psychologically unwell. 71% are female.

3 RESULTS

In line with other research findings, data show that the first two hurdles of the digital divides have not been fully past.

First Digital Divide: Costs

There is a sharp difference between those psychologically well and those psychologically unwell in the decision of buying a monitoring product and assistive technology in general. Those who are psychologically well tend to adopt devices which are not specifically designed for older adults and would tend to avoid monitoring. Interestingly to note, when those psychologically well are involved in testing or are curious about the products, they would tend to feel stressed about being monitored and to refuse technology.

Whereas those psychologically unwell would firstly be influenced by others in this decision and tend to accept any kind of monitoring or technology which might support/ accompany/ or give a sense of being secure.

For those psychologically well regardless of their physical status, in the decision of NOT buying the A4A Solution, the 'technology alternatives on the market' is the less important factor, while all others (price, privacy, not being monitored and false alarms) are very relevant and relevant for about 60% of the participants.

For those physically well and psychologically unwell, the price matters the most in the decision for not buying the product (60% rated 5 this reason in not buying the A4A). Similar for the category of those both physically and psychologically unwell, price is the most important factor for not buying the product

(71%), followed by privacy (57,2%). Reticence for being monitored is the least important factor in the decision of not buying the product. A negative weak correlation exists between the willingness to pay more for the A4A Solution as long as they pay themselves the price (Pearson correlation -.418).

Second Digital Divide: Relevance

The A4A Index

'The A4A Index' was conceived to assess the robustness of the new technology proposed for the seniors and their next of kin. The index puts together

7 key-measures of the new technology: 'alarm', 'notification', 'anormal behaviour', 'control ON/OFF', 'ADLs' cognitive decline' and 'mental unwellness'.

A reliability test has been conducted, which measures the internal consistency of the index, that is, how closely related the set of 7 items are as a group. The reliability test is conducted through Cronbach's Alpha, which is .917. That shows a high reliability (significantly higher than .800).

On a scale from 1 to 5, the mean of the A4A Index is 3.76 and the median is 4 and the mode, the most common value, is 5 (19.5% rated with 5 each of the A4A features). High relevance of the A4A Solution was found among 48% (Those who rated 4 or 5 each feature of A4A) and No relevance of the A4A Solution was found among 20.7% (Those who rated 1 or 2 each feature of A4A).

The A4A Solution is seen as being very relevant and relevant by the large majority of the participants. The Alarm feature (*'Proactively generate an ALARM to the sounds" HELP" or repetitive beats which might mean "HELP" to a next-of-kin or professional carer'*) is seen as being the most relevant. The following 3 advantages: easy to install, relevance of the alarm, and the price, are moderately correlated to the relevance of the Index A4A (Pearson Correlation .469; .468 and .405 respectively).

The advantage of 'notifications of cognitive decline' issignificantly stronger correlated to the Index A4A (Pearson Correlation .679).

The Q4 Index "Worries" has a high reliability, and weakly predicts the relevance of the A4A Solution (Adjusted R Square= .208).

Table 1: The relevance of the A4A features.

	1ST	2ND	3RD	4TH	5TH	6TH	7TH
PH+PS+	Alarm	'I am well' Notification	Identifying mental problems	Functional & Cognitive decline	ADLs	Control ON/OFF	Anormal behaviour
PH-PS+	Alarm	'I am well' Notification	Identifying mental problems	ADLs	Anormal behaviour	Functional & Cognitive decline	ON/OFF Control
PH+PS-	Alarm	Functional & Cognitive decline	'I am well' Notification	ADLs	Anormal Behaviour	ON/OFF Control	Identifying mental problems
PH-PS-	Alarm	'I am well' Notification	Identifying mental problems	Functional & Cognitive decline	Anormal behaviour	ADLs	Control ON/OFF

The Q8 Index ‘the advantages which influence the decision to buy the A4A Solution’ and The Q9 Index ‘the features which influence the decision NOT to buy the A4A Solution’ are not reliable, meaning that we cannot conclude on each advantage/feature of the A4A Solution as counting in the decision to buy or not to buy the product.

Therefore, we have decided to group the participants in 4 groups, according to the gerontographic segmentation in order to account for more subtle preferences and characteristics of the participants in relation to the A4A Solution. Hence, the co-creation process was key in giving the right direction towards the development of the new technology.

In line with literature review, the results show that there is a wide range of requirements because older adults (henceforth, OA) are a very heterogeneous population, with many people over the age of 80 continuing to live independently, while others show frailness and advanced cognitive impairment. The fact that their next of kin (henceforth, NOK) and formal care providers (henceforth PCP) are involved in the A4A co-creation process as end-users and buyers make the process more complex.

Those who exhibit psychological wellbeing and have relatively good health conditions, regardless of their age-related physical limitations and still living independently would tend to adopt technology which support their positive ageing. They look for volunteering and community involvement as well as new communication channels, and opt for smartphone for tracking their physical activity (Paul and Spuru, 2021). The healthy and independent older adults and their professional and next of kin carers think about A4A device as having some basic functions:

- the control over the device and over the alarm,
- notification or pre-alarm to be sent to NoK or PCP if they do not wake up,
- avoiding false alarms and easy to install.

They merely show that they want to keep their independence and control over their life, while NoK and PCP look to avoid overloading.

Those who Exhibit a Low Psychological Well-Being. would tend to adopt technology who make them feel more secure, have a feeling of being supported and cared for. Hence, they would tend to adopt remote sensors or wearables.

The Third Digital Divide: Ethics and More

As Ethics and data protection is a growing point of concern for older adults. As people age and become more and more accustomed to the new technologies they are also more informed about the data protection and ethics. Their next of kin claim more and more transparency and information regarding data collection and processing. Hence, they tend to refuse monitoring until they reach the point of trading their privacy for security.

Though, ethics and data protection is not the only point of their concern. New monitoring products require an ecosystem to be in place for them to optimal function. Data interpretation is one point of concern as current monitoring products add to the burden of caring by asking their next of kin or professionals to step in.

4 DISCUSSION

Research shows that there is a correlation between physical activity and subjective well-being on the one hand, and health and longevity on the other hand, even there is still much more to learn about the relation between the two. Growing evidence from neuroscience, biology and social studies shows that there is a strong connection between physical activity, emotional wellbeing and functional independence but more research is needed to establish the causation direction and moderators.

With respect to monitoring technologies, the first and second digital divides have not been yet overcome. That is because one needs a whole system in place for monitoring, such as the caregiver, the system to run, data interpretation. All these further restrict even the HAVEs to access monitoring technologies because the ecosystems which allow monitoring products to work are not in place. More, even when they are, it is cheaper to opt for monitoring only for accidents, i.e. fall alarms.

A4A Solution would infer on the ADLs and IADLs to detect early anomalies in functional independence. These early detected anomalies are much related either to the deterioration of physical activity, emotional or cognitive wellbeing.

5 CONCLUSIONS

We see that the first digital divide has not passed and the costs of the assistive technologies and their services stay high and widen the gap between the have and have nots. With respect to the second digital divide, we have also noted that the heterogeneity of the older adult population leads to different expectations based on the health and functional status. A third digital divide is about to happen, with respect to data and ethics of the technologies, the need to control the device clearly expressed by the participants.

To some extent, technology drives away emotions in a process aimed at optimizing care. A nurse ceases to hold someone's hand because of the pulsometer, children and older adults are monitored, surveillance technologies are on the rise, doctors may gradually become redundant due to AI of decision support systems, and biometrics can tell you about subtle changes in your body even before you can perceive them (Harrari, 2018).

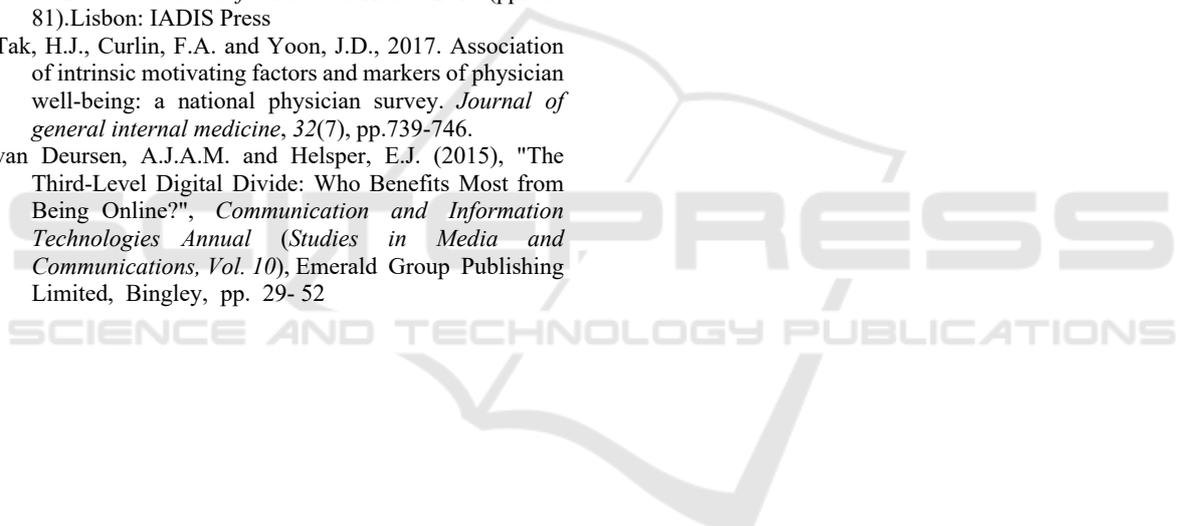
ACKNOWLEDGEMENTS

This work was performed in the frame of the national project „Increasing research capacity and national and international visibility of the Ana Aslan International Foundation (FAAI), through promoting research results”, SMART-BEAR, PN-III-P3-3.6-H2020-2020-0174, nr. 61/2021 and EU project AAL4All (AAL-2021-8-164-CP) funded by the AAL Programme and co-funded by the European Commission and the National Funding Authorities of the partner countries.

REFERENCES

- Battersby, L., Fang, M.L., Canham, S.L., Sixsmith, J., Moreno, S. and Sixsmith, A., 2017, July. Co-creation methods: informing technology solutions for older adults. In *International Conference on Human Aspects of IT for the Aged Population* (pp. 77-89). Springer, Cham.
- Creber RM, Maurer MS, Reading M, Hiraldo G, Hickey KT, Iribarren S. Review and analysis of existing mobile phone apps to support heart failure symptom monitoring and self-care management using the Mobile Application Rating Scale (MARS). *JMIR mHealth and uHealth*. 2016 Jun 14;4(2):e5882.
- Czarnuch, S. and Mihailidis, A., 2011. The design of intelligent in-home assistive technologies: Assessing the needs of older adults with dementia and their caregivers. *Gerontechnology*, 10(3), pp.169-182.
- De Bruin, E.D., Hartmann, A., Uebelhart, D., Murer, K. and Zijlstra, W., 2008. Wearable systems for monitoring mobility-related activities in older people: a systematic review. *Clinical rehabilitation*, 22(10-11), pp.878-895.
- Delello, J.A. and McWhorter, R.R., 2017. Reducing the digital divide: Connecting older adults to iPad technology. *Journal of Applied Gerontology*, 36(1), pp.3- 28.
- Grzes M, Hoey J, Khan S, Mihailidis A, Czarnuch S, Jackson D, Monk A. Relational approach to knowledge engineering for pomdp-based assistance systems with encoding of a psychological model. KEPS 2011. 2011 Jun 12:77.
- Istrate, D., Vacher, M. and Serignat, J.F., 2008. Embedded implementation of distress situation identification through sound analysis. *The Journal on Information Technology in Healthcare*, 6(3), pp.204-211.
- Karahasanović, A., Brandtzæg, P.B., Heim, J., Lüders, M., Vermeir, L., Pierson, J., Lievens, B., Vanattenhoven, J. and Jans, G., 2009. Co-creation and user-generated content—elderly people's user requirements. *Computers in Human Behavior*, 25(3), pp.655-678.
- Katt JA, Speranza L, Shore W, Saenz KH, Witta EL. Doing Well: A sem analysis of the relationships between various activities of daily living and geriatric well-being. *The Journal of genetic psychology*. 2009 Sep 30;170(3):213-26.
- Madara Marasinghe K. Assistive technologies in reducing caregiver burden among informal caregivers of older adults: a systematic review. *Disability and Rehabilitation: Assistive Technology*. 2016 Jul 3;11(5):353-60.
- Moschis, G.P., 1996. *Gerontographics: Life-stage segmentation for marketing strategy development*. Greenwood Publishing Group.
- Moschis, G.P., 2003. Marketing to older adults: an updated overview of present knowledge and practice. *Journal of Consumer Marketing*, 20(6), pp.516-525.
- Moschis, G.P., Mathur, A. and Sthienrapapayut, T., 2020. Gerontographics and consumer behavior in later life: Insights from the life course paradigm. *Journal of Global Scholars of Marketing Science*, 30(1), pp.18-33.

- Moschis, George P. 2019. Consumer Behavior over the Life Course. Research Frontiers and New Directions, Springer Nature.
- Nimrod, G., 2013. Applying Gerontographics in the study of older Internet users. Participations: Journal of Audience & Reception Studies, 10(2), pp.46-64
- Ostir GV, Berges IM, Ottenbacher KJ, Fisher SR, BarrE, Hebel JR, Guralnik JM. Gait speed and disability in older adults. Archives of physical medicine and rehabilitation. 2015 Sep 1;96(9):1641-5.
- Paul, C. and Spiru, L., 2021. From Age to Age: Key Gerontographics Contributions to Technology Adoption by Older Adults.
- Rantz MJ, Zwiygart-Stauffacher M, Flesner M, Hicks L, Mehr D, Russell T, Minner D. The influence of teams to
- Spiru, L., Marzan, M., Paul, C., Velciu, M. and Garleanu, A., 2019. The Reversed Moscow Method. A General Framework for Developing age-Friendly Technologies. In *Multi Conference on Computer Science and Information Systems, MCCSIS 2019–Proceedings of the International Conference on e-Health 2019* (pp. 75-81). Lisbon: IADIS Press
- Tak, H.J., Curlin, F.A. and Yoon, J.D., 2017. Association of intrinsic motivating factors and markers of physician well-being: a national physician survey. *Journal of general internal medicine*, 32(7), pp.739-746.
- van Deursen, A.J.A.M. and Helsper, E.J. (2015), "The Third-Level Digital Divide: Who Benefits Most from Being Online?", *Communication and Information Technologies Annual (Studies in Media and Communications, Vol. 10)*, Emerald Group Publishing Limited, Bingley, pp. 29- 52

**EMERALD GROUP PUBLISHING**
SCIENCE AND TECHNOLOGY PUBLICATIONS